

AD A 0 39737

Effects of Water Vapor on Thermal Shield Materials

Chemistry and Physics Laboratory
The Ivan A. Getting Laboratories
The Aerospace Corporation
El Segundo, Calif. 90245

19 April 1977

Interim Report

APPROVED FOR PUBLIC RELEASE;
DISTRIBUTION UNLIMITED

Prepared for

SPACE AND MISSILE SYSTEMS ORGANIZATION
AIR FORCE SYSTEMS COMMAND
Los Angeles Air Porce Station
P.O. Box 92960, Worldway Postal Center
Los Angeles, Calif. 90009





This report was submitted by The Aerospace Corporation, El Segundo, CA 90245, under Contract F04701-76-C-0077 with the Space and Missile Systems Organization, Deputy for Advanced Space Programs, P.O. Box 92960, Worldway Postal Center, Los Angeles, CA 90009. It was reviewed and approved for The Aerospace Corporation by S. Siegel, Director, Chemistry and Physics Laboratory. Lieutenant A. G. Fernandez, SAMSO/YAPT, was the project officer for Advanced Space Programs.

This report has been reviewed by the Information Office (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

Arturo G. Fernandez, Lt. USAF Project Officer

To eph Gassmann, Major, USA

FOR THE COMMANDER

Floyd R. Stuart, Colonel, USAF

Deputy for Advanced Space Programs

CURITY CLASSIFICATION OF THIS PAGE (When Data Entered)	READ INSTRUCTIONS			
REPORT DOCUMENTATION PAGE	BEFORE COMPLETING FORM 3. RECIPIENT'S CATALOG HUMBER			
SAMSO-17: -77-91	(9 Tellical rest			
TITLE (and Subticto)	5. THE OF REPORT & PERIOD COVER			
EFFECTS OF WATER VAPOR ON THERMAL	Inter im			
SHIELD MATERIALS.	S. PERFORMING ORG. REPORT NUMBER			
	TR-0077(2270-30)-1			
Alfred A. Fote	(F)4701-76-C-0077)			
/	10. PROGRAM ELEMENT, PROJECT, TAS			
PERFORMING ORGANIZATION NAME AND ADDRESS	AREA & WORK UNIT NUMBERS			
The Aerospace Corporation El Segundo, California 90245				
. CONTROLLING OFFICE NAME AND ADDRESS	11) 19 April 1977			
Space and Missile Systems Organization	13. NUMBER OF PAGES			
Los Angeles, Calif. 90009 4. MONITCRING AGENCY NAME & ADDRESS(II different from Controlling Office)	ce) 18. SECURITY CLASS. (SLIBIA TOPORT)			
4. MONITCRING AGENCY NAME & ADDRESS(II different from Controlling Office	Unclassified			
	150. DECLASSIFICATION/DOWNGRADING			
6. DISTRIBUTION STATEMENT (of this Report)				
Approved for public release; distribution unlir	mited			
	ACCEUSUR for			
	NTIS White Section (
and the state of t	unt from Roport) DOG Butt Section (UNANNOUNCED JUSTIFICATION			
7. DISTRIBUTION STATEMENT (OF the abstract entered in block 20, 7. Chib. C.				
	BY			
IS. SUPPLEMENTARY NOTES	DISTRIBUTION/AVAILABILITY CODE DIST. AVAIL. ANG/OF SPECIA			
18. SUPPLEMENTARY NOTES 19. KEY WORDS (Continue on reverse side if necessary and identify by block nu Silvered Teflon	DISTRIBUTION/AVAILABILITY CODE DIST. AVAIL. ANG/OF SPECIA			
19. KEY WORDS (Continue on reverse side if necessary and identify by block nu Silvered Teflon Thermal Shields	DISTRIBUTION/AVAILABILITY CODE DIST. AVAIL. ANG/OF SPECIA			

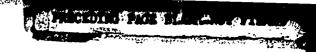
Three of the materials commonly used to insulate spacecraft from solar radiation are aluminized mylar, aluminized kapton, and silvered teflon. Damage to or deterioration of these materials would lead to large scale temperature excursions of the spacecraft. One possible mechanism for such deterioration would be the occurrence of high humidity prior to launch. A study was conducted to determine the vulnerability of these materials to humidity. It was found that aluminized mylar and aluminized kapton remain unaffected, but that silvered teflon is seriously damaged in a period of hours

FORM DD FORM 1473

I. INTRODUCTION

The vulnerability of several flexible thermal control materials to damage under conditions of high humidity was investigated. Deterioration of these materials would destroy their ability to protect spacecraft from excessive heating caused by orbital solar radiation. Exposure to a humid environment could result from failure of an air conditioning unit at any time prior to launch.

In this study, samples of 1/4 mil aluminized mylar, 1 mil aluminized kapton, and 2 mil silvered teflon, in the form of squares 1/2 to 3 in. on a side, were exposed to various controlled humidities and examined for deterioration. The samples were used, as received, without being cleaned or treated. It was discovered that the aluminized mylar and aluminized kapton were unaffected by the water vapor; whereas, the silvered teflon was severely damaged in a few hours.



II. EFFECT OF SEA WATER VAPOR

An artificial sea water solution was prepared from a standard recipe. One sample of each material was exposed to the vapor of this solution in a sealed container at 24°C for three days. During this time, dry nitrogen was slowly percolated through the solution. The bursting bubbles served to propel the dissolved salts into the vapor, which would otherwise contain only water molecules.

After exposure, each sample was divided in half. One set of samples was exposed to a vacuum for two days. The second set remained in a normal environment for 14 days; then it was also exposed to a vacuum for two days. The reflectivity of the samples in the wavelength region of 1 to 5 μ m was measured. This wavelength corresponds to the near-infrared region of the solar spectrum.

Under these conditions, it was found for both sets that the aluminized mylar and aluminized kapton suffered no deterioration; however, the silvered teflon was severely damaged. This damage took the form of a gentle separation of the silver film from the teflon. The separation was made manifest by the appearance and growth of white patches over approximately 50% of the surface area observable from the teflon side. There was no visible effect on the silvered side. Flexing of the material or a gentle contact then caused the silver film to fracture in these areas.

A subsequent test was made on the silvered teflon with the sea water solution replaced by distilled water. The occurrence of damage of the same type and magnitude indicated that the water vapor alone, not the dissolved salts, was responsible for deterioration.

III. EFFECT OF HUMIDITY ON SILVERED TEFLON

In order to determine the range of humidity over which silvered teflon would deteriorate, samples of the material were suspended above aqueous solutions of LiBr in sealed containers. LiBr in water lowers the vapor pressure by a known amount³ without contributing to the vapor itself.

Table I gives the results of these tests in terms of the percent of the surface area damaged. In experiments 1 and 2, samples were exposed to humidities of 97%, 92%, 87%, 76%, and 55% at 24°C and observed after specified time periods. In experiments 3 and 4, several other samples were observed after 24 and 48 hours, respectively.

There is considerable variation in the measurable damage for different samples exposed to identical conditions. However, it can be noted that severe damage will occur after only a few hours at the higher humidities.

Ninety percent humidity at 24°C appears to be the marginal condition under which some damage, but not severe damage, can occur.

It is obvious that the amount of water vapor present, at a given temperature, determines the degree of damage. Table II gives the equivalent humidities, i.e., same water vapor content, at temperatures other than those studied. This chart can be used to predict the degree of damage to be expected under the conditions given. Conditions such as those shown in the second column will produce moderate to severe damage (>5%). The third

column presents conditions that produce marginal (0.1 - 5%), whereas the last presents conditions that yield negligible damage (<0.1%). The validity of this table has been verified by testing samples under conditions of 100% humidity at 18°C and 55% humidity at 14°C.

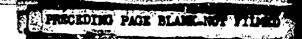
Table I. Damage to Silvered Teflon Caused by Exposure to Humidity

Experiment No.		Humidity (%)				
	Time (hr)	92	87	76	55	
i	1	0	0	0	0	0
	2	0.1	0	0	0	0
	3.5	1	0	0	0	0
	6	2	0	0	0	0
	24	7	3	0	0	0
	96	10	3	0	0	0
2	1.5	0	0	0	0	0
	2.5	20	0	0	0	0
	5	20	0	0	0	0
	48	60	0.5	0.5	0	0
3	24	12	2	5		
4	48	6			0	0

Table II. Equivalent humidity versus temperature for occurrence of damage to silvered teflon.

and the state of the section of the

Temperature (°C)	Equivalent Humidity				
	Severe Damage (>5%)	Marginal Damage (0.1 - 5%)	Negligible Damage (0.1%)		
18			100-78		
21		100	92-66		
24	97	92-87	76-55		
27	82	78-74	65-47		
29	71	67-64	58-40		
32	66	57-54	48-34		
35	51	49-46	41-29		
38	44	42-40	35-25		



REFERENCES

- 1. Uhlig, H. H., ed., The Corrosion Handbook, John Wiley and Sons, Inc., 1948, p. 1121.
- 2. MacIntyre, F., "The Millimeter of the Ocean," Scientific American, May 1974.
- 3. National Research Council, <u>International Critical Tables</u>, McGraw Hill Book Company, Inc., 1933.

THE IVAN A. GETTING LABORATORIES

and the control of th

The Laboratory Operations of The Aerospace Corporation is conducting. experimental and theoretical investigations necessary for the evaluation and application of scientific advances to new military concepts and systems. Versatility and flexibility have been developed to a high degree by the laboratory personnel in dealing with the many problems encountered in the nation's rapidly developing space and missile systems. Expertise in the latest scientific developments is vital to the accomplishment of tasks related to these problems. The laboratories that contribute to this research are:

Aerophysics Laboratory: Launch and reentry aerodynamics, heat transfer, reentry physics, chemical kinetics, structural mechanics, flight dynamics, atmospheric pollution, and high-power gas lasers.

Chemistry and Physics Laboratory: Atmospheric reactions and atmospheric optics, chemical reactions in polluted atmospheres, chemical reactions of excited species in rocket plumes, chemical thermodynamics, plasma and laser-induced reactions, laser chemistry, propulsion chemistry, space vacuum and radiation effects on materials, lubrication and surface phenomena, photosensitive materials and sensors, high precision laser ranging, and the application of physics and chemistry to problems of law enforcement and biomedicine.

Electronics Research Laboratory: Flectromagnetic theory, devices, and propagation phenomena, including plasma electromagnetics; quantum electronics, lasers, and electro-optics; communication sciences, applied electronics, semiconducting, superconducting, and prystal device physics, optical and acoustical imaging: atmospheric pollution; millimeter wave and far-infrared technology.

<u>interials Sciences Laboratory</u>: Development of new materials; metal matrix composites and new forms of carbon; test and evaluation of graphite and ceramics in reentry; spacecraft materials and electronic components in nuclear weapons environment; application of fracture mechanics to stress corrosion, and fatigue-induced fractures in structural metals.

Space Sciences Laboratory: Atmospheric and ionospheric physics, radiation from the atmosphere, density and composition of the atmosphere, aurorae and airglow; magnetospheric physics, cosmic rays, generation and propagation of plasma waves in the magnetosphere; solar physics, studies of solar magnetic fields; space astronomy, x-ray astronomy; the effects of nuclear explosions, magnetic storms, and solar activity on the earth's atmosphere, ionosphere, and magnetosphere; the effects of optical, electromagnetic, and particulate radiations in space on space systems.

THE AEROSPACE CORPORATION El Segundo, California